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Quarterly Progress Report, Dec 1992 - Feb 1993
ONR Contract Number N00014-91-J-1577
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Yale University Department of Computer Science

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Our work continues, in the area of planning and control in realistic domains:

Our planning work focused on (1) the extending and revising concepts that allow plans and their simulations to be represented more transparently and (2) the application of these declarative concepts to encode knowledge for the detection and analysis of plan failures.

- The representation language for plan transformation rules has been extended such that a single plan transformation can make modifications in several subplans.
- XFRM-ML, a PROLOG-like language for the implementation of failure diagnosis and plan revision has been extended and partly revised.
- the knowledgebase for the detection and analysis of plan failures that can occur in the performance of an achievement task when it is carried out using *imperfect sensors*, *imperfect control*, an *inaccurate and highly incomplete world model*, and *with other tasks* has been elaborated. The knowledge base comprises now:
 1. a failure taxonomy for the robot delivery domain. The taxonomy contains failure descriptions (ca. 15) like *unachieved goal*, *never achieved goal*, *never tried goal*, *achievement failure*, *task interference*, different types of *perception failures*, etc. It also describes the subsumption relationship between them.
 2. Implementation of a transformation rules for plan revision in the robot delivery domain. Categories of these plan revisions comprise (1) plan revisions that deal with plan failures that have not been detected by the plan interpreter, (2) plan revisions that work for failures that are reported by the plan interpreter, (3) plan revisions to prevent task interferences, (4) plan revisions to prevent failures.
- The integration of the subsystem into XFRM is on its way.

Our work on processing of uncertain sensor data has focused on that addition of efficient segmentation to our interval-based segmentation algorithms. In general, the problem of associating data points with models is combinatorial. However, we have observed that the speed with which a problem requiring data-model association can be solved increases drastically when the data are organized into spatial groups. Spatial organization has two main advantages: first, it permits the exploitation of low-level feature matching to explicitly associate groups of data with a model, and it also makes it possible to implicitly associate groups of data with a model during the fitting process. We are now engaged in testing this idea on real applications, and improving the performance of the decision-making algorithms when data-model association must be performed.

Activities:

Greg Hager: "Efficient Solution of Large Systems of Nonlinear Constraints With Inexact Data and Explicit Termination Criteria," presentation at the Conference on Numerical Computation with Automatic Result Verification in LaFayette Louisiana, Feb 25-Mar 1.

Drew McDermott: "Transformational Planning of Reactive Behavior," presentation at the MIT Workshop on Autonomous Underwater Vehicles, Cambridge, MA, January 26-27.

Drew McDermott: Attended DARPA strategy session on Intelligent Real-time Planning and Control. Arlington, VA, February 3-4.

STATEMENT
approved for public release
Distribution Unlimited

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Drew McDermott: Attended annual workshop of DARPA/Rome Lab Planning Initiative PI meeting, in his capacity as member of the Technical Review Board for that initiative, San Antonio, TX, February 24-26.

Publications:

Greg Hager, On Comparing Statistical and Set-Based Methods in Sensor Data Fusion (with S. Engelson and S. Atiya). To be presented at the 1993 IEEE International Conference on Robotics and Automation, May, 1993.

Drew McDermott, Transformational planning of reactive behavior. Yale Computer Science Report 941, December, 1992.

Personnel Support:

- *Graduate Students (full time):* Sean Engelson, Michael Beetz, and Pedro Marun
- *Post-doc (half-time):* Hemant Tagare
- *Secretary (half-time):* Paula Murano

Expenditures:

The accompanying table shows the figures for expenditures to date, including amounts committed but not actually spent.

Overall Status and Plans:

We're still working on experimental validation of our planning/reaction system. Preliminary results are described in Tech Report 941, which is enclosed.

Next steps:

- Full integration of the plan revision techniques into the general transformational framework of XFRM.
- Extensive experiments with the failure analysis and plan revision techniques in a simulated uncertain world.
- Tech Report describing the plan revision system.
- start thinking about: plan revision as part of plan execution, revising plans after execution failures are signalled, plan revision and the relation to on-line map learning

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LEDGER DESCRIPTION	AMOUNT BUDGETED	COMMITTED (NOT PAID)	PAID TO DATE	TOTAL EXPENSES	REMAINING BALANCE
NON-LADDER ACAD& RES APPTS	0	4,477.05	4,477.05	8,954.10	-8,954.10
FACULTY SUMMER COMP	51,599		50,377.56	50,377.56	1,221.44
CLERICAL & TECHNICAL	25,719	8,736.49	30,040.10	38,776.59	-13,057.59
STUDENT ASST.	135,450	3,461.52	35,938.62	39,400.14	96,049.86
OTHER YALE STU- DENTS	0		15,632.	15,632	-15,632.
DIRECT WAGES	0		344.	344.	-344.
EMP. BENEFITS	29,014.	4,466.95	26,727.66	31,194.61	-2,180.61
D/P SUPPLIES	0	404.	2,713.78	3,117.78	-3,117.78
D/P SVS.	38,579	8,108.00	18,285.	26,393..	12,186.
MINOR EQUIPMENT	0		379.	379.	-379.
MISC MATERIALS	0		55.17	55.17	-55.17
D/P SOFTWARE	6,000		2,633	2,633	3,367
FREIGHT & TRANSPORTATION	0	60.00	736.13	796.13	-796.13
PHOTOCOPYING	6,430	781.00	2,927.46	3,708.46	2,721.54

LEDGER DESCRIPTION	AMOUNT BUDGETED	COMMITTED (NOT PAID)	PAID TO DATE	TOTAL EXPENSES	REMAINING BALANCE
PRINTING	0		313.80	313.80	-313.80
MISC SERVICES	0		270	270	-270
COMMISSIONS	0		25.	25.	-25.
OTHER PROFESSIONAL		152.32		152.32	-152.32
D EQUIPMENT MAINT	0		581.16	581.16	-581.16
TRAVEL (DOMESTIC)	12,860	1,303.00	9,290.06	10,593.06	-2,266.94
TRAVEL (FOREIGN)	0		2,913.98	2,913.98	-2,913.98
CONF.& SEMINAR FEES		215.00		215.00	-215.00
OFFICE SUPPLIES	3,215	5.68	885.61	891.29	2,323.71
PERIODICALS	0	00	1,576.89	1,576.89	-1,576.89
POSTAGE	0	39.84	794.49	834.33	-834.33
TUITION REMISSION	69,162		25,416.	25,416.	43,746.
HEALTH INS.	0		1,444.	1,444.	-1,444.
TELEPHONE	3,215	186.11	412.07	598.18	2,616.82
DATA PROC. EQUIPMENT	189,000	10,683.	67,752.25	78,435.25	110,564.75
INDIRECT (OVERHEAD 68.0%)	212,215	22,057.12	142,645.85.	164,702.97	47,512.03
TOTAL:	782,458	65,177.08	445,587.69	510,764.77	271,693.23
OVERHEAD ANTICIPATED:					109,971.07
SPENDING BALANCE AVAILABLE AS OF 02/24/93:					161,722.16